THE CAMBRO-ORDOVICIAN OF THE BORBOREMA PROVINCE

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Key words: Transition stage, Eo-Paleozoic, molasse, pull-apart basin, foredeep, intradeep, foreland, shear zone, basin-formation tectonics.

ABSTRACT

This paper describes some volcano-sedimentary deposits that characterize the time interval from Neoproterozoic III to the early Ordovician, typical of the Borborema Province, Northeast Brazil. They are usually designated molassic deposits and comprise coarse-grained immature rocks with common lateral gradation to pelitic lithologies of continental environments. The volcanism varies, but is mostly acid to intermediate.

Two major types of basins may be identified: The first type is connected with the formation and evolution of pull apart depressions along the major shear zones (or lineaments) as part of the escape-tectonics phase of the Borborema Province (LL type basin). The second type is formed by foreland (foredeeps) and intradeeps (distal rifts) related to the late and post-tectonic evolutionary processes of the Sergipano Belt, a "miogeoclinal" orogen positioned at the northeast border of the São Francisco Craton.

In both cases, the preservation of these deposits – usually scarce and scattered throughout the province – was only possible due to the immediate protection by younger Paleozoic covers (Silurian and younger) of syneclises and Mesozoic rifts (generated above these syneclises). Presently, the thickest and largest occurrences of these deposits do not crop out as they are beneath the Paleozoic basins according to geophysical and other subsurface data. Some of these Eo-Paleozoic rifts have been pointed out as precursor rifts for the development of the Parnaiba Syneclise.

RESUMO

Este trabalho descreve coberturas vulcano-sedimentares que caracterizam o intervalo de tempo entre o Neoproterozóico III e o início do Ordoviciano, relativamente bem representados na Província Borborema, Nordeste do Brasil, e que são geralmente chamados de depósitos molássicos. Tratam-se de rochas clásticas imaturas, grosseiras com passagens laterais para termos pelíticos, de natureza continental, e o vulcanismo é variável, a maioria das vêzes de caráter ácido a intermediário.

Dois tipos de depósitos/bacias são identificados: O primeiro ligado a evolução de depressões extensionais ao longo de zonas de cisalhamento, da fase de tectônica extrusional da província proterozóica da Borborema. (tipo LL). O segundo tipo constitui bacias de antepaís (antefossas) e riftes distais ligados aos processos de evolução tardi a pós-tectônicos do orógeno Sergipano, da borda nordeste (e natureza "miogeclinal") do Cráton do São Francisco.

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Em ambos os casos a preservação destes depósitos – hoje muito escassos e rarefeitos se deveu à proteção imediata de coberturas paleozóicas (silurianas e mais jovens) das sinéclises e de riftes mesozóicos (gerados à partir das sinéclises). As ocorrências mais expressivas, em espessura e extensão destes depósitos estão no substrato das bacias paleozóicas, conforme dados de geofísica e outros de subsuperfície. Alguns destes riftes eo-paleozóicos atuaram inclusive como riftes precursores da Sinéclise do Parnaiba.

INTRODUCTION

The so-called Cambrian-Ordovician or molassic basins of the Borborema Province are scattered throughout small areas in the western part (first group) and in the southeastern part (second group) of the province, as remaining fractions protected from erosion by the Silurian-Devonian cover rocks and subsequent Phanerozoic history.

They are volcano-sedimentary and sedimentary sequences with outcrop areas from < 10 km^2 to 1250 km^2, the latter are preserved beneath Paleozoic (interior basins, Parnaiba, Tucano, Jatobá, Araripe) and Mesozoic-Cenozoic (continental marginal basins) cover rocks. Previous larger extensions and thicknesses (as well as preexisting physical connections) have been removed by several cycles or regional geomorphic evolution, during Paleozoic times (many cycles) and from the Upper Cretaceous to the present (at least four cycles). Only the Jaibaras basin (from the first group, described below) and the Lagarto-Tobias Barreto basin (second group) are sufficiently well preserved for such designations of sedimentary basins, and they display other geological characteristics that permit reasonable litho-stratigraphic interpretations.

The usual designation of "basins" for all occurrences is perhaps inappropriate, and attempts for correlation among them are still problematic. Generally, most of the litho-stratigraphic units have informally been established. The analysis of the regional geologic information, and the scarce geochronologlcal determinations presently available are only enough to refer these basins/ occurrences to the long time interval between the end of the Neoproterozoic and the first half of the Ordovician period. This is enough to show the preliminary nature of the present stage of knowledge.

The application of the concept of "cratonic sedimentary sequences" to this series of occurrences, as it was suggested by Soares et al, 1984 is useful, but it demands some additional comments. These cover rocks may be envisaged as the first sedimentary sequences of the South American Platform, but they may also be considered as tectonic and lithological records for the epilogue of the Brasiliano Cycle. In fact, they are representing volcano-plutonic and sedimentary associations of the "stage of transition" of that platform , as first ascribed by Almeida, 1967. They are recording an intermediate stage between the conditions of the Neoproterozoic mobile belts and the tectonic conditions of stability (since the Lower Ordovician) that has lasted throughout Paleozoic times.

Two main groups of occurrences are distinguishable on the basis of main lithological, structural characteristics and the present geographic-geologic position:

A. Occurrences in the western periphery of the province, with known extensions into the basement of the Parnaiba basin (Parnaiba Province), which follows the trends of main shear zones there positioned. Such shear zones or shear belts or "lineaments" have played an important role in the development of the present geologic-geographic framework and general shape of the Borborema Province. For all these cases,volcano-sedimentary associations are predominating. In these basins, discrete plutonism and associated fissural intrusives are present in the surrounding areas (sometimes far from the basins themselves).

It is possible that many other similar type of occurrences could have existed in the geological past, far from the Parnaiba syneclise. But, the central part of the Borborema Province has acted as shield area throughout most of the Paleozoic time, with many uplift events and their consequent denudation cycles. The present occurrences along the periphery of the Parnaiba syneclise are therefore probably relicts of much more extensive basins. This fact is being gradually confirmed by studies on the substratum of the syneclise (see Nunes et al, 1993), where the presence of such deposits is very expressive (protected by the Silurian cover).

B. Occurrences situated in "molassic intradeeeps" and "foredeeps" (foreland basins) developed by the Sergipano fold belt, near the southeastern border of the province. For these cases, magmatic events are generally absent, and psammitic and psephitic sedimentary rocks are the predominant lithologies, derived from adjacent source areas, either from the fold belt itself or from the high grade rocks of the basement uplifts of the craton (São Francisco Craton). The Paleozoic sedimentary cover (Recôncavo-Tucano-Jatobá basins) played some role in the preservations of these occurrences, but this was not so important as in the case of those above mentioned group A.

Additional occurrences may be found out for the future (at least, they are being expected) either associated with these groups or elsewhere, with the advent of more detailed investigations, such as detailed surface and subsurface geologic mapping. The significant occurrences in the basement of the Parnaiba basin (part of group A) were only discovered in this decade, with the intensification of geophysical surveys. Until recently, only the scattered group of small and discontinuous occurrences preserved on the periphery of that basin were known. Actually, the formalization of the litho-stratigraphic formal units and the general geologic knowledge of these

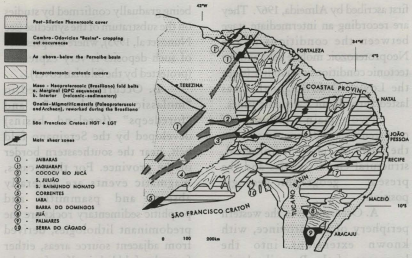

Figura 1 - General sketch of the Borborema Province (with emphasis on the Cambro-Ordovician ocurrences).

basins and their evolution are still far from complete and they will need many improvements (and a better review) for the future.

The general geological knowledge, concerning all of the outcropping occurrences may only be classified as preliminary, despite the fact that almost all basins have been geologically mapped at a scale of 1/100,000 or larger ones. There are still many open questions, such as stratigraphic classification and related aspects, which could not be taken into consideration during the previous geological mapping.

GROUP A BASINS: EXTRUSIONAL TYPES

Tectonic Conditioning

These occurrences synthe- sized in Fig. 1 (based on Cunha, 1986 and Nunes et al, 1993, among others) have two fundamental common features or preconditions:

a) Their histories are associated with the very long "shear zones" of the Borborema Province during both basin-forming (tensional) and basin-modifying (compressional/ transpressional) tectonic phases, and they are characterized by filling hollows and residual depressions of larger previous dimensions, such as *pull apart* types of structural spaces.
b) They were only preserved near the Silurian-Devonian covers, which during the present geomorphic cycle (initiated in the

Upper Cretaceous) are undergoing processes of erosion and removal. So, these same types of covers have also protected these Cambrian-Ordovician occurrences/basins from their complete vanishing. Since the beginning of this geomorphic cycle, the Paleozoic sedimentary cover start to be partially removed and then the "Cambrian-Ordovician basins" begun their process of exposure and consequent strong erosion.

The framework of the "shear zones" extends from the Parnaiba Province basement to the Continental Margin (and from there to the Pan-African domain, in the African territory). The basin-forming tectonics have mostly been interpreted as transtensional events of these shear zones, so forming rhomboidal grabens (*pull apart* structures) and controlled the sedimentation. The basin-modifying tectonics (one or more phases) were controlled by the number and degree of transpressional movements along the shear zone, so producing the discontinuous (idiomorphic) style folding, that displays variable degrees of intensity, from "very weak" to "strong", according with the classification of Kingston et al, 1983. The resultant lithological associations show evidences of thermodynamic transformations ranging from diagenesis (different intensities) up to the beginning of greenschist facies.

Under the regional scale, the tectonic process was not limited to the surroundings of the shear belts. Throughout the western portion of Ceará and eastern Piaui, associated wlth the same tectonic process there are dike-swarms, fissural intrusives, some pegmatite fields and anorogenic plutonism of alkaline affinities ("intraplate" or A type). They are approximately of the same range of ages, between 580 and 520 Ma (mostly Rb/Sr determinations), and their association with the volcano-sedimentary occurrences constitute one of the most important (most conspicuous) part of the several aspects of this late tectonic stage ("Transition stage") of the Borborema and Pan African Provinces.

The conjunction of all these events seems to be consistent with the phenomenon known as "escape tectonics" or "extrusion" (after Tapponnier et al 1986 and others) that is a tectonic response to continued convergence of continental plates after the cessation of subduction (or its temporary impediment). It involves lateral adjustments and "escape" of pieces of the mosaic of blocks and fold belts subsequent to the main collisional events, in order to accommodate additional steps of convergence. This interpretation was first proposed for this province by Brito Neves & Cordani , 1991, as representative for the Eo-Paleozoic time interval, and it was considered to be due to ongoing convergence stresses between Neoproterozoic continental plates (e. g. São Francisco-Congo and São Luis-West Africa.).

This period represents the transition of tectonic conditions from the stage of mobility of Neoproterozoic fold belts ("geosynclinal stage") to the succeeding stage of greater stability(Phanerozoic "orthoplatform") from the Silurian to the Jurassic, when several epicontinental marine transgressions took place where the provinces of Parnaiba and Borborema are presently positioned.

Once again, during Paleozoic times, the importance of the "shear zones" could be demonstrated. That importance was not only restricted to the formation, deformation and preservation of the the Eo-Paleozoic volcano-sedimentary basins. Therefore, during the the Silurian and Devonian periods, the Sobral (or Transbrasiliano, NNE-SSW) and the Picos-Santa Inês, NW-SE) shear zones were preferential sites of subsidence (because of their younger thermal ages) , and constituted important depocenters for the evolution of the Parnaiba basin (as demonstrated by Cunha, 1986).

Stratigraphy and Sedimentation

Table I tries to show that the filling of the rhomboidal grabens occurred in different rapid pulses, under continental environments, with more or less associated volcanism, preceding and succeeding the emplacement of some anorogenic plutons.

The basal breccias and polymictic conglomerates of the sedimentary sequence (Massapê Formation, Eojarc , Iara basal psephites, etc.) are proximal deposits of alluvial cones formed during dry climates, with characteristics of prismatic lithosomes. Lateral facies variations are very common, channels, fluvial plains and lake deposits (e. g. Pacujá Fm.) of different shallow depths. Distal equivalents of these psephitic rocks display predominant plane-parallel stratification and other primary structures formed by waves and storms and by sub-aerial exposures (mud-cracks, bioturbation, etc.), which are overlaid by immature psephitic and/or psammitic deposits. Primary structures in such deposits show evidences that they were formerly much more extensive in area.

Significant magmatism (effusive volcanic rocks, pyroclastic rocks, etc.) in these basal units is only presented in the area of São Julião/ Mandacaru, near the Piaui-Ceará boundary, mostly basalts and andesitic basalts).

The last sedimentary pulse (Aprazivel/Eojcg/Tamboril formations) is usually following anorogenic plutonism and it is preserved is preserved only at the neighborhoods of the major faults, and this comprises alluvial fans (torrential, and even some deposits from talus slope) characterized by unusual irregular shapes and containing clastic fragments of metrical dimensions. Occurrences of clasts of all subjacent lithologies, sedimentary, volcanic, plutonic, and even from rocks of the basement are common, representing good sampling of all adjacent source-areas. Only rarely the deposits of this last phase laterally grade to distal lacustrine facies.

The total thicknesses of the preserved sequences are unknown, due to the nature and shapes of the occurrences and the lack of stratigraphic wells. There are some estimations for thicknesses of Jaibaras and São Julião basins, both in the range of 2000 up to 3000 m.

Up to now, generally, even the most distal and pelitic lithologies have been described as not fossiliferous. However, this is probably reflecting the absolute lack of investigation by specialists. Structure similar to ichnofossil, different kinds of bioturbation, and other evidences of organic activities have commonly been observed (in Pacujá formation, "Eojarc" and equivalent deposits) without the wishful help of a specialist.

Volcano-sedimentary (or more accurately, volcano-plutono-sedimentary) deposits are typical of all the basins and consistent with the expectations of the tectonic stage that they represent. Only in Cococi, both volcanism and plutonism were still not directly observed (inside of the basin itself), but the sediments and associated mineralizations show some indirect evidences, and therefore, some additional detailed investigations are being required. Also, as it was mentioned above, regional development of dike swarms and contemporaneous anorogenic plutonism (outside the basin) constitute part or the same general geotectonic process.

Magmatism and Mineralization. Metamorphism.

Volcanic rocks are present at various stratigraphic positions in different occurrences. There are some cases where they occurred at the beginning of the development (São Julião). In most of the cases, they occur in the middle of the stratigraphic section, preceding the intrusion of the granites. There are some other occurrences where the volcanism may be found throughout the entire stratigraphic section, even with cases where some volcanic rocks are cutting across the granites and the highest portions of the stratigraphic column.

Although the geochemical knowledge of these volcanic rocks is defective, there are good indications that they represent continental volcanism of intraplate settings. They have suffered (with some exceptions) some process of hydrothermal alteration. In Jaibaras basin, the geochemical compositions are highly variable, with the predominance of basic to intermediate volcanic rocks. In São Julião, the basaltic rocks are predominant (80% for the particular case of the basal sequence) . In fact, the geochemical character of the volcanic rocks of Parapui (Jaibaras) and Catolé (São Julião) demonstrates mutual affinities, and they are presenting coherence for an interpretation involving volcanism of continental rift zones.

The plutonism is also controlled by the system of faults, and it displays petrographic and geochemical characteristics of anorogenic bodies, intraplate or A type, with development of modest aureoles of contact metamorphism. Also there are mineralogical and isotopic evidence for superimposed hydrothermal alterations. The total amount of anorogenic plutons emplaced throughout the whole western portion of Ceará State and eastern part of Piauí State during this same tectonic stage is still not

COMPARED LIPHOSTRATIGRAPHIC COLUMNAR SECTIONS OF THE CAMBRO-ORDOVICIAN FORMATIONS OF THE BORBOREMA PROVINCE – NORTHEAST BRAZIL

TIME	JAIBARAS/JAGUARAPI NW CEARÁ	COCOCI/RIO JUCÁ SW CEARÁ	SÃO JULIÃO/MANDA-CARU	IARA/RIO DAS CUNCAS S.CEARÁ	CORRENTES/CURIMATÁ S.PIAUÍ	BARRA DOS DOMINGOS BUIQUE-PERNAMBUCO
SILURIAN-DEVONIAN	SERRA GRANDE GROUP	SERRA GRANDE GROUP	SERRA GRANDE GROUP	CARIRI/MAURITTI Fm	SERRA GRANDE GROUP	TACARATU Fm
O R D O V I C I A N C A M B R I A N UPPER NEOPROTEROZOIC	Coarse polymictic breccias and conglomerates with clasts of all rocks below vvvvvvvvvvvvvvvvvvvvvvv Fayalite-granite Micrograntes Felsic dikes vvvvvvvvvvvvvvvvvvvvvvv Basic, intermediate to acid volcanics Basic dikes Minor volcanoclastics Immature sanstones, arkoses, shales and siltstones Locally graywackes and conglomerates Polymictic conglomerates clasts and matrices variable with the source rocks	Coarse polymictic conglomerates, arkoses, calciferous conglomerates vvvvvvvvvvvvvvvvvvvvvvv Minor Intrusive Fissure veins Slates, Calciferous shales and siltites Ferruginous siltstones Polymictic breccias and microbreccias, arkosic sandstones and conglomerates	Coarse polymictic breccia with clasts of all rocks below vvvvvvvvvvvvvvvvvvvvvvv Granites, Granodiorites, Pegmatite Rapakivi facies vvvvvvvvvvvvvvvvvvvvvvv Siltstones Ferruginous sandstones Polymictic rudites and graywackes - - - - - - - - - - - - - - - - Basalt (80%) and andesitic basalts, dacites, rhyolites, Pyroclastics tuffs	vvvvvvvvvv?vvvvvvvvvv Arkosic and volcaniclastic sandstones Basic volcanics Polymictic breccias and conglomerates + Bimodal volcanism vvvvvvvvvvvvvvvvvvvvv Siltstones Arkosic Sandstones + Bimodal volcanism Basal Paraconglomerates (diamictites) vvvvvvvvvv?vvvvvvvvvv	vvvvvvvvvv?vvvvvvvvvv Slates, siltstones, minor graywackes vvvvvvvvvv?vvvvvvvvvv Reddish quartzites vvvvvvvvvv?vvvvvvvvvv Graywackes, arkosic sandstones and siltstones	PLUTONIC – (Syenites, granites) VOLCANIC – (Trachytes, microsyenites) SEDIMENTARY (tuffs, ashes, cineritic sandstones and siltstones, clays) COMPLEX
Neoproterozoic	**Ubajara Group (QPC)** 11- Aprazível Fm 10- Meruoca granite 09- Parapuí Suite 08- Pacujá Fm 07- Massapê Fm	**Orthogneisses and Migmatites** 6- ɛojcg (Aprazível Fm) 5- ɛojf (Pacujá Fm) 4- ɛojarc (Massapê Fm)	**"São Julião" Metasediments (QPC)** 3- Tamboril Fm 2- "Mandacaru" Granite 1- Catolé Fm	**"Cachoeirinha" Group (BVAC)** Iara Fm	**Gneisses and Granites (Casa Nova Group)** Correntes-Curimatá Unit	**Gneisses and Granites (undifferentiated)** Anonymous
	Costa et al, 1975 Goraieb et al, 1988	Oliveira et al, 1974	Farina, 1980 Parente & Fuck, 1987	Barbosa et al, 1970 Parente et al, 1990	Winge, 1968 Nunes, 1993	Zanini & Farina, 1980

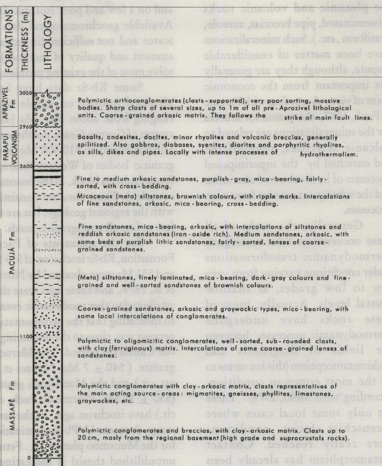

Figura 2 - An ideal section for the Jaibaras Group. Lateral transitions between Massapê and Pacujá formations are common. Modified from Costa et al., 1975.

well known, but the available information suggests some tens of occurrences. The same is true for the cases of associated dike-swarms.

Several different types of cupriferous mineralization characterize the plutonic and volcanic rocks (disseminated, pipe breccias, aureole, stratiform , etc.). Such mineralizations have been matter of considerable dispute, although they are generally not important from the economic point of view. According with Parente & Fuck, 1987,. the precursor sources for the mineralizations are related to volcanic activities, remobilized and enriched by the superimposed processes of hydrothermal alteration and the subsequent granite formation processes.

Generally, the rocks of all these occurrences have undergone thermodynamic transformations under conditions varying from very low to low grades, at shallow crustal levels. Actually, most of these rocks have undergone thermodynamic processes between the fields of diagenesis and anchimetamorphism (this last seems to be the most common condition, according with Melo, 1978). There are only some local cases where greenschist facies conditions were really reached. Contact metamorphism has already been mentioned, occurring as relatively local and modest aureoles of granites, both inside and outside (in this case, on rocks of the basement) of the main basins). Hydrothermal and associated processes, as mentioned before, have affected volcanic and volcanoclastic rocks and even some granitic plutons.

Age

The general stratigraphic position as late Neoproterozoic to pre-Silurian was formerly emphasized in this text,based mostly on preliminary information of the regional geology and on a few and poor isotopic data. Available geochronological data is scarce and not sufficient (in terms of amount and quality of methods) to solve most of the existing problems.

Some Rb-Sr data have been obtained (mostly on whole rock) ranging from about 580 Ma (dike-swarm of Coreau-Ceará, northwest of Jaibaras basin) to 510-500 Ma (some granitic bodies of Western Ceará, in Santa Quitéria block, in the basement complex). These data are consistent with the regional geology, but are too few to face all stratigraphic needs.

For the sediments of Pacujá Formation, Rb-Sr isochrons of 535 Ma and 551 Ma were obtained by Novaes et al, 1979., and these ages were then attributed to ther modynamic events, so indicating that the sedimentation process was close to the beginning of the Cambrian period. The Meruoca granite (540 $\pm$ 7 Ma, Novaes et al, op. cit.) and the Mandacaru granite (550 $\pm$ 10 Ma, Parente & Fuck, op. cit.) have isochron ages in the same range. A recent U/Pb determination for the Mucambo pluton (A . Fetter, unpublished thesis) is indicating a value of 532 Ma, which is confirming the range of Neoproterozoic/ Phanerozoic ages for these rocks.

Additionally, there are several other granites in the region of western Ceará (Santa Quitéria block) with the same general characteristics, piercing basement rocks, which have yielded Rb-Sr isochrons with similar but younger ages, around 510-500 Ma

(Tavares Jr. 1992), near the end of the Cambrian period.

Based on these few data, the assumption of a Cambrian-Ordovician age remains suitable, due the lack of a better geochronological background. The upper stratigraphic limit remains as an open question, it is generally attributed to be younger than the Silurian sedimentation of the syneclises ("β" cratonic sequence), awaiting new data and some improvements in the dating techniques. It is necessary to add that hydrothermal processes could have affected the accuracy and resolution power of the employed methodologies (Rb-Sr and K/Ar), and all data have to be seen with caution. It is possible that only a small part (or none at all) of the Ordovician period was involved in these phenomena, that because of their nature and characteristics are difficult to correlate from one occurrence to another, even in basins of the same province. The use of the word Ordovician is only a kind of precaution and is not based on reliable geochronological data.

The geological information is limited and there are no geochronological data for the other occurrences displayed in Table I, such as Correntes/Curimatá and Barra do Domingos. The level of knowledge is not much superior than that one of the synthesis proposed in the table, there is much uncertainty because of the lack of real and systematic field work. Photo-interpretation and brief geological surveys are the only available data to this present moment.

GROUP B BASIN: ASSOCIATED WITH THE SERGIPANO FOLD BELT

The Lagarto-Tobias Barreto foredeep is situated in south of Sergipe State and part of the northeast of Bahia State. It was developed during the evolution of the Sergipano fold belt on the northeast edge of the São Francisco-Congo craton (the foreland of the fold belt) at the end of the Neoproterozoic. This large basin displays major part covered by sediments of the the adjacent younger Phanerozoic basins (Recôncavo, Tucano and Sergipe-Alagoas), and so doing their lithostratigraphic units are only being exposed along a small triangular area of south Sergipe and northeast Bahia. Actually, this area of occurrence and good expositions is truly a horst, among rifts formed during the Mesozoic.

In this triangular area, there are the best exposures of the Palmares Formation (Figure I, no. 9) that presents characteristics of post-orogenic sedimentation for it is occurring overlying the Estância Group, a foreland equivalent to the Vaza-Barris Group of the Sergipano fold belt, a probably Neoproterozoic orogen.

The Estância Group, as above mentioned, is a pile of sedimentary rocks (clastic rocks, most of them) almost not deformed above the basement of the craton, and it is the cratonic equivalent of the litho-stratigraphic units of the fold belt to the north, specially of the southern part of the fold belt, where "miogeoclinal" conditions have predominated. The

Estância Group displays typical stable shelf sediments and idiomorphic style of folding (weak and discontinuous) and it is probably Neoproterozoic in age, based on some regional correlations (also based on some stromatolitic structures and some unpublished isotopic data). The idea is that the Estância Group was part of the prior continental extension of the São Francisco (Bambui) Supergroup, in this particular case, a small part preserved not deformed above the foreland (foredeep basin) of the Sergipano belt.

The Palmares Formation occurs above the Estância Group (and above the adjacent cratonic basement), separated by an unconformity and it becomes predominant in terms of outcrop all over the foreland as a very continuous molassic cover.

Other molassic deposits occur in the interior of the Sergipano fold belt (Figure 1: 8, Juá ;: 10, Serra do Cágado), positioned as intradeeps defined by normal faults. In Juá (southwestern of Jeremoabo-Bahia) and in the ridges of Serra do Cágado (north of Nova Canudos, Bahia) the areas of occurrences are now of modest dimensions, but they could be probably larger in the geological past. These are composed by very immature psammites and psephites, which are clearly late-orogenic sediments, deposited after the climax of the Brasiliano diastrophism. Such deposits have been considered correlate with those of the Palmares Formation because of lithologlcal similarities and the position in the stratigraphic sequence (late to post-Neoproterozoic metasediments of Vaza-Barris Group and prior to the-Silurian sediments of the adjacent Paleozoic Basin), and also based upon some geochronological data. Like in the case of the Palmares Formation, there are additional occurrences of these rift deposits beneath the adjacent Phanerozoic basins, according with information from deep wells.

Palmares Formation (Molasse of the Foreland)

The Palmares Formation (Figure 1 :no. 9) was first described and proposed at the north end of the main area of occurrence by Silva Filho et al, 1978, in Sergipe. Recently, this formations was recognized and described farther south, in the area of the Real River, in Bahia State, by Saes & Vilas Boas, 1989. These southern occurrences are similar in both lithological associations and sedimentary environments (Figures 3 and 4, vertical sections are being described). The basal stratigraphic section (proximal facies) lies with a clear unconformity upon the Lagarto Formation, this one being the top of the Estância Group. These rocks are characterized by the predominance of monomictic breccias and polymictic conglomerates with variable stratigraphic organization and structures, including massive, plane-parallel and cross-bedding. Lateral-vertical variations of facies are common, with transitions to rhythmites. Fragments of limestones are present among the variable types of clasts, probably originated from the reworking of the Estância Group (Acauã Formation , from the middle part of the section of this group).

These are typical alluvial fan deposits, related to sharp topographic relief with many events of rejuvenation. In the northern part of the area of occurrence, Silva Filho et al., 1978b, identified sedimentary structures indicating source areas to the north, to the interior of the fold belt (as typical molasse in the classic sense). In the area of Real River, south of the triangular area of occurrence, there are indications for source area variable, with predominance of and WNW ESSE directions.

In this area, where the lithostratigraphic section is much more complete, the upper part includes a sequence of psammitic sediments varying from medium to fine-grained, with both plane-parallel and cross-bedding structures and large range of colors from greenish to reddish., with rare intercalation of conglomerates and conglomeratic sandstones (Figure 3). For the whole section it is estimated a thickness around 3,000 m. All general parameters and primary structures strongly suggest deposition in shallow water by the activity of a flood of high density (due to concentration of sand), with additional evidence of a high energy (marine) environment and strong reworking, probably by waves, so leading Saes & Vilas Boas, op. cit. to propose the deposition in a fan delta, under the influence of tides.

In his recent doctoral thesis (and subsequent papers), D'EL-Rey Silva, 1992 tried to modify the above interpretation for the Palmares Formation, denying its unconformity above the Estância Group, and trying to reunite under the same stratigraphic designation the Lagarto (stratigraphic top of Estância Group, sandstones, siltstones) and the Palmares Formation (he used the name "Lagarto-Palmares" Formation) that would have a large development to the north (to the interior of the fold belt). This opinion – frequent in references of this area - must be handled with respect, but also with reserves, since the mapping carried out by D'EL Rey Silva have covered only a narrow EAST-WEST fraction of the northern edge of the foreland basin. Our field observations do not confirm the assumptions of this author, even though the area demands further geological studies.

Intradeep Deposits (Juá Formation)

The Juá Formation (Figure 1, 8) occupies a system of older grabens reactivated by the Mesozoic tectonics of the Tucano Basin). These grabens follows general strikes NNE-SSW, and they were developed on metamorphic rocks of the Macururé Group (distal meta-volcano sedimentary sequences of the Sergipano belt) and on granitic plutons of late tectonic character, in the central-north portion of the Sergipano fold belt, few kilometers southwest of Jeremoabo-Bahia.

Following the principal fault lines, this unit presents a proximal facies (Meneses Filho et al., 1968) of clast-supported,coarse-grained, immature polymictic conglomerates, poorly organized, without matrix, or with matrix that is typically sandy, immature and coarse-grained. The clasts are varied, mostly consisting of granitoides, but including acid, intermediate and basic meta-volcanic rocks as well as diverse kinds of metamorphic rocks. It comprises a proximal sequence of debris flows with lateral transitions to conglomeratic

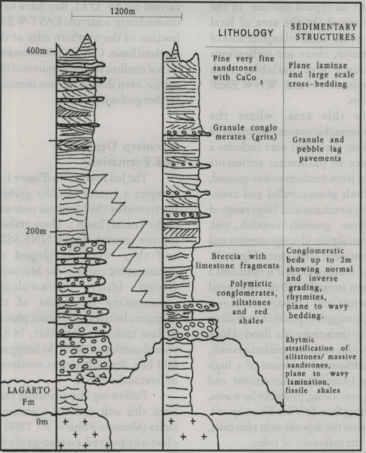

Figura 3 - Vertical profiles (P1 and P2) showing breccia, conglomerate, rhythimite, and violet sandstone facies. Real river valley, basal part of the Palmares Formation. From saes & Vilas Boas 1989.

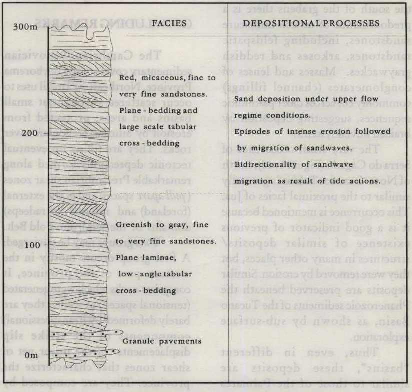

Figura 4 - Vertical profile of the red - and - green sandstone facies. Uppermost Section of the Palmares Formation. From Saes & Vilas Boas 1989.

sandstones and discontinuous fluvial channel conglomerates probably derived from areas of sharp relief that have undergone frequent processes of rejuvenation. Metamorphic structures are rare, only local occurrences of an weak schistosity (sericite-bearing) may be found.

Far from the fault lines, to the south of the grabens there is a predominance of coarse immature sandstones, including feldspatic sandstones, arkoses and reddish graywackes. Masses and lenses of conglomerates (channel fillings) commonly cut across older psammitic sequences, suggesting depostion by braided fluvial systems.

The very small occurrence of Serra do Cágado (Figure 1: 10), north of Nova Canudos-Bahias is generally similar to the proximal facies of Juá. This occurrence is mentioned because it is a good indicator of previous existence of similar deposits/ structures in many other places, but they were removed by erosion. Similar deposits are preserved beneath the Phanerozoic sediments of the Tucano Basin, as shown by sub-surface exploration.

Thus, even in different "basins", these deposits are similar to those of the Palmares Formation, playing the role of lithologlcal records of late to post orogenic activities of the Sergipano fold belt, whit accumulation of detritical material derived from regional tectonic uplift (involving the fold belt and the surrounding cratonic region).

Only these last-described group of deposits deserves the classification of molassic sedimentation, because of their origin, meaning and stratigraphic position, accordingly to the original definition of the term in classical geotectonic texts. It is necessary to stress that, because is very common the wrong way in Brazil to use "molasse" almost as synonymous for Eo-Paleozoic deposits.

CONCLUDING REMARKS

The Cambrian-Ordovician sedimentary covers of the Borborema Province, Northeast of Brazil uses to occur scattered throughout small basins and areas, protected from erosion by Silurian Devonian cover rocks. They are filling up eventual tectonic depressions formed along remarkable Precambrian shear zones (*pull apart* spaces) and in the external (foreland) and internal (intradeeps) domains of the Sergipano Fold Belt.

Two groups may be envisaged: A first group occurs mostly in the western part of the province, It comprises rocks which were generated (tensional spaces) as well as they are barely deformed by (transpressional) components of the strike slip displacements of the major net of shear zones that characterize the province. They are composed by clastic immature sediments and volcano-sedimentary associations, with subordinate anorogenic plutonism and dike-swarms. This group is as kind of lithological records for the (final) phase of escape-tectonics of the branching systems of Neoproterozoic orogens that build up the Borborema Province. So, theymay be classified as extrusional -LL type- sedimentary basins, according with the classification system of Kingston et al., 1983.

The second group is particularly associated wlth the final phase of development of the Sergipano Fold Belt (southeastern of the province), and they are playing the role of sediments of foredeep ("Lagarto-Tobias Barreto" foreland basin) and intra deeps (some interior fault bounded troughs). They comprise immature clastic sediments, mostly coarse-grained, with lateral gradations to colorful psammites of continental environments, with some superposed marine reworking Occurrences of volcanic rocks were not recorded up to now in this second group. Only for this second group or basins the classical term of molassic deposits is suitable, because the source-areas for the sediments were the then just-deformed fold belt (to the north) and the surrounding uplifts of the cratonic area (to the south).

All available geochronological data, up to now, are in the reconnaissance scale. They are pointing out Cambrian age for both types of basins, may be with some final activities near the early-beginnings of the Ordovician. Fossiliferous records use to be very poor or not enough studied. Both geochronological and paleontological aspects are crucial demands for a better knowledge of these basins and they remain as true open questions.

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